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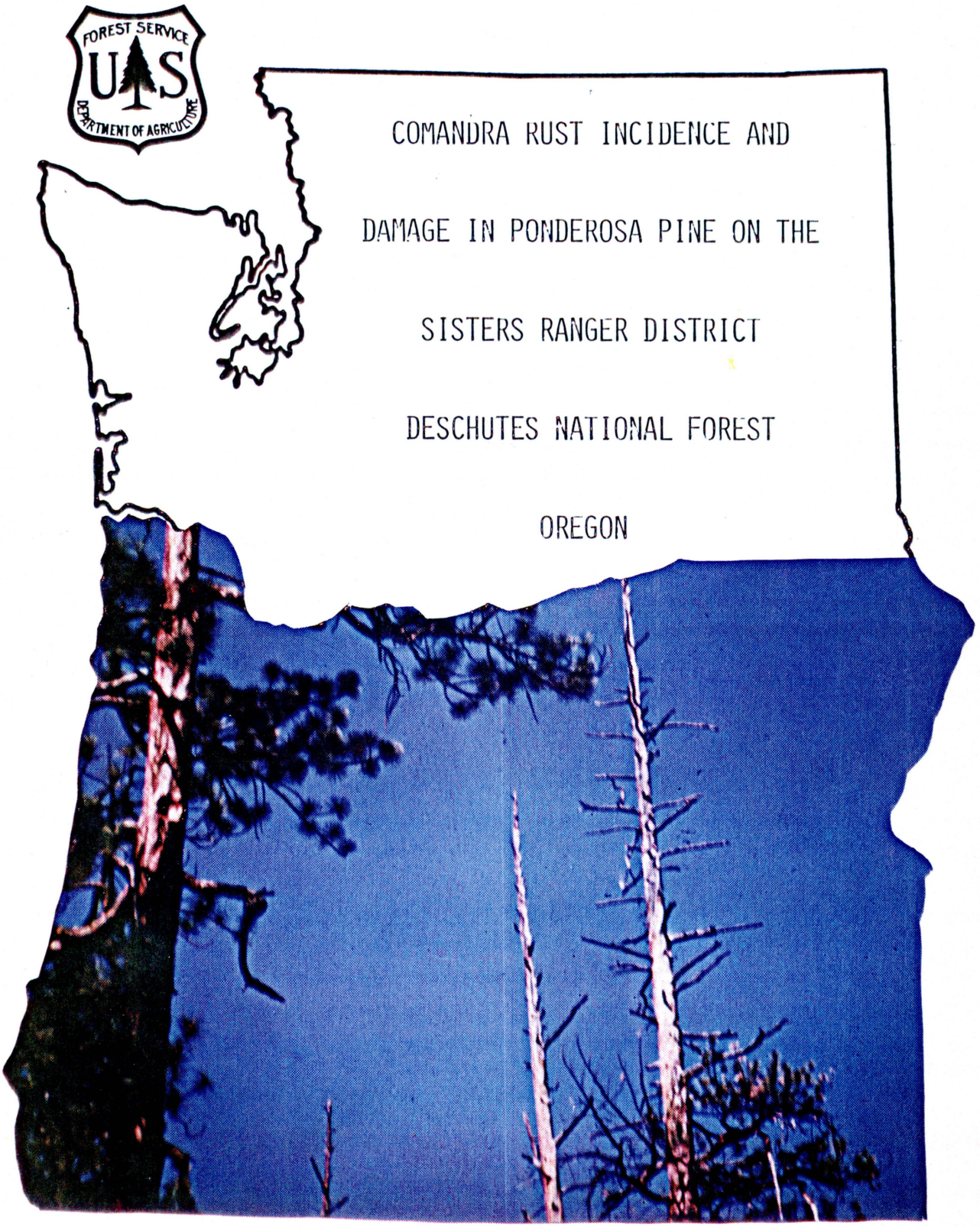
Forest Pest Management
Pacific Northwest Region



COMANDRA RUST INCIDENCE AND

DAMAGE IN PONDEROSA PINE ON THE

SISTERS RANGER DISTRICT

DESCHUTES NATIONAL FOREST

OREGON

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COMANDRA RUST INCIDENCE AND DAMAGE IN PONDEROSA PINE ON THE SISTERS RANGER DISTRICT, DESCHUTES NATIONAL FOREST, OREGON

by

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Abstract

In a 2,430 hectare (6,000 acre) ponderosa pine stand in central Oregon, 1 percent of the stems, containing 6 percent of the wood volume, are visibly infected by comandra rust. Infection, which occurs primarily in large diameter trees, is manifested exclusively as top-kill and accounts for an average cubic volume loss of 4.4 percent per infected tree. Recent infections were absent in the stand. Change in factors affecting rust epidemics could cause infection and mortality in potential crop trees and result in stand understocking. Management alternatives to minimize future infections are discussed.

Introduction

Comandra rust, caused by the fungus *Cronartium comandrae* Pk., is sporadic and occasionally damaging in eastside ponderosa pine *(Pinus ponderosa* Laws.) forests of Oregon and Washington (Childs 1968). Lodgepole pine *(Pinus contorta* Dougl.) is seldom infected in the Pacific Northwest (Hadfield 1977), although the species is a common host in the Rocky Mountains (Krebill 1968). Comandra rust, a branch and stem disease, is inconspicuous on small trees and often attributed to other causes in larger trees. When present, comandra rust commonly causes mortality in young-growth and top-kill in mature and overmature pines.

Bastard toadflax *(Comandra umbellata* Nutt.), a forb inhabiting dry, open sites, is the alternate host for the rust in the Pacific Northwest (Figure 1). Its presence is essential for completion of the disease cycle. In summer, wind-borne aeciospores from diseased pines infect the alternate host (Ziller 1974). There is no pine-to-pine spread of the disease. During the growing season, the rust forms urediniospores on the alternate host and these reinfect other bastard toadflax. In autumn, hair-like telia form on upper and lower leaf surfaces of the alternate host (Figure 1). Eventually, basidiospores, which are wind-borne and infect pine needles, are formed on the alternate host. Severe infection by basidiospores has been found in lodgepole pine stands in the Rocky Mountains where the closest bastard toadflax plants were more than a mile away (Mielke et al. 1968).

A few months after infection, yellow spots appear on the pine needles. Rust mycelium grows from infected needles into the adjacent branch or stem, causing the bark to become discolored and swollen. Spermagonia appear on the discolored bark in late summer or fall, one to several years after infection. Bright, orange-red aeciospores from aecial pustules are released from bark occupied by spermagonia the year before (Figure 2). Wind-borne aeciospores infect bastard toadflax in summer, completing the life cycle.

Infected pine branches can survive for several years because the fungus grows slowly. Cankers originating far from the trunk are eventually eliminated by branch death (Childs 1968). Cankers originating near the trunk usually continue to grow into the stem and girdle it, causing top-kill. The fungus slowly grows down the stem until the tree is killed. Rodents commonly chew the swollen infected tissues and young stem cankers often appear as oval, gnawed areas centered at the branch where infection started (Figure 3).

Trunk infections in mature and overmature trees are inconspicuous from the ground until crown symptoms appear (Childs 1968). The first symptoms are dead branches in a narrow zone around the point where the fungus entered the stem (Figure 4). Above this zone, the crown thins and eventually dies, forming characteristic "spike-tops" (Figure 5). As the fungus grows down the trunk (about 5 cm, 2 inches/year), the uppermost branches die. Mortality of top-killed trees make take a century in old-growth pine (Childs 1968).

In some old-growth stands, several dead-top trees occur in close proximity (Figure 6). These dead-tops may contain considerable wood, representing a substantial portion of the stand volume. Rust-killed tops of ponderosa pine become resin impregnated, making them unmerchantable. On the other hand, resin-impregnation delays wood decay and thus decreases failure potential for recently killed tops, a safety consideration in recreation areas.

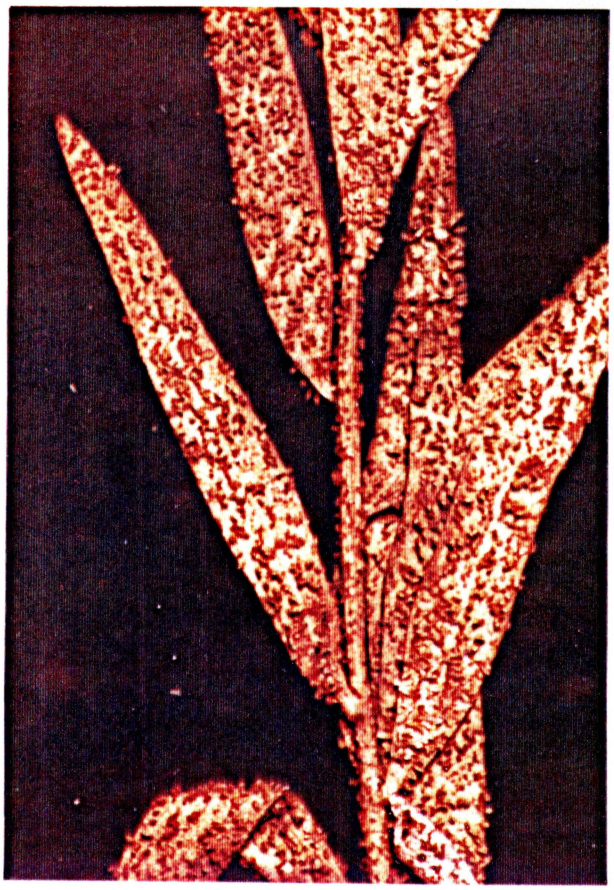

Figure 1.--Bastard toadflax (*Comandra umbellata*) with orange telia of *Cronartium comandrae*.

Figure 2.--Orange-red aeciospores in aecial pustules of *Cronaritum comandrae* on an infected ponderosa pine.

Figure 3.--Comandra rust stem canker on young-growth ponderosa pine.

Figure 4.--Branch killing of ponderosa pine by comandra rust.

Figure 5.-- Top-kill due to comandra rust in old growth ponderosa pine.

Figure 6.--Spike-tops caused by comandra rust in an old-growth ponderosa pine stand.

Damage caused by comandra rust in the Pacific Northwest has been poorly documented. Objectives of this evaluation were to determine incidence and damage caused by comandra rust in visibly affected stands of mature to overmature ponderosa pine on the Deschutes National Forest. The evaluation will provide impact data on a local basis and also establish a base from which to compare future infection and damage should an epidemic occur.

Evaluation Methods

Survey Area Description

The evaluation was conducted near the Metolius River on the Sisters Ranger District, Deschutes National Forest, Oregon (Tps. 12 and 13 S., R. 9 E.) (Figure 7). The stand is uneven-aged and consists primarily of ponderosa pine *(Pinus ponderosa* Laws.). Some Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii)*, incense-cedar *(Libocedrus decurrens* Torr.), and western larch *(Larix occidentalis* Nutt.) occur at the higher elevations.

The stand is Site Class IV (Site Index 70, base 100 years). The survey area corresponds to the ponderosa pine/bitterbrush-manzanita/needlegrass plant community (Volland 1976). Bitterbrush *(Purshia tridentata* (Pursh) DC.) and greenleaf manzanita *(Arctostaphylos patula* Greene) are principal understory species.

Elevation of the survey area averages 1,050 m (3,500 feet). Annual precipitation is approximately 75 to 100 cm (30 to 40 in). January mean minimum and July mean maximum temperatures are -8° and 29° C (17.6° and 84.2° F), respectively (Sisters, Oregon climatic data). Soils are a loamy coarse sand, well drained, and derived from air-laid pumice and lava colluvium (Volland 1976).

The survey area is managed by the U.S. Forest Service and has received light selection cuts and small clearcuts. Most old-growth pines, at least along major roadways, have been retained for aesthetic value. Part of the "Head of the Metolius" point of interest (65 ha, 160 ac) and the Metolius Research Natural Area (650 ha, 1,600 ac) are included in the survey area.

Survey Methods

In August 1976, approximately 2,430 ha (6,000 ac) were systematically ground surveyed with 80 variable plots (BAF 20) and 80 fixed area, circular plots, (.004 ha, .01 ac) located at 400 meter-(20 chain) intervals along primarily E-W transects (Figure 8). Plot centers were the same for both variable and fixed plots. All trees (including seedlings) not recorded in variable plots were tallied if they fell within fixed plots. Only ponderosa pine were recorded regardless of merchantability or condition (dead or alive).

The following data were recorded at each plot: (1) elevation, (2) aspect, (3) percent slope, and (4) presence of alternate host. Each tree on a plot was described as to: (1) d.b.h., (2) age group, (3) crown class, (4) total height, and (5) disease index. The following disease index was used:

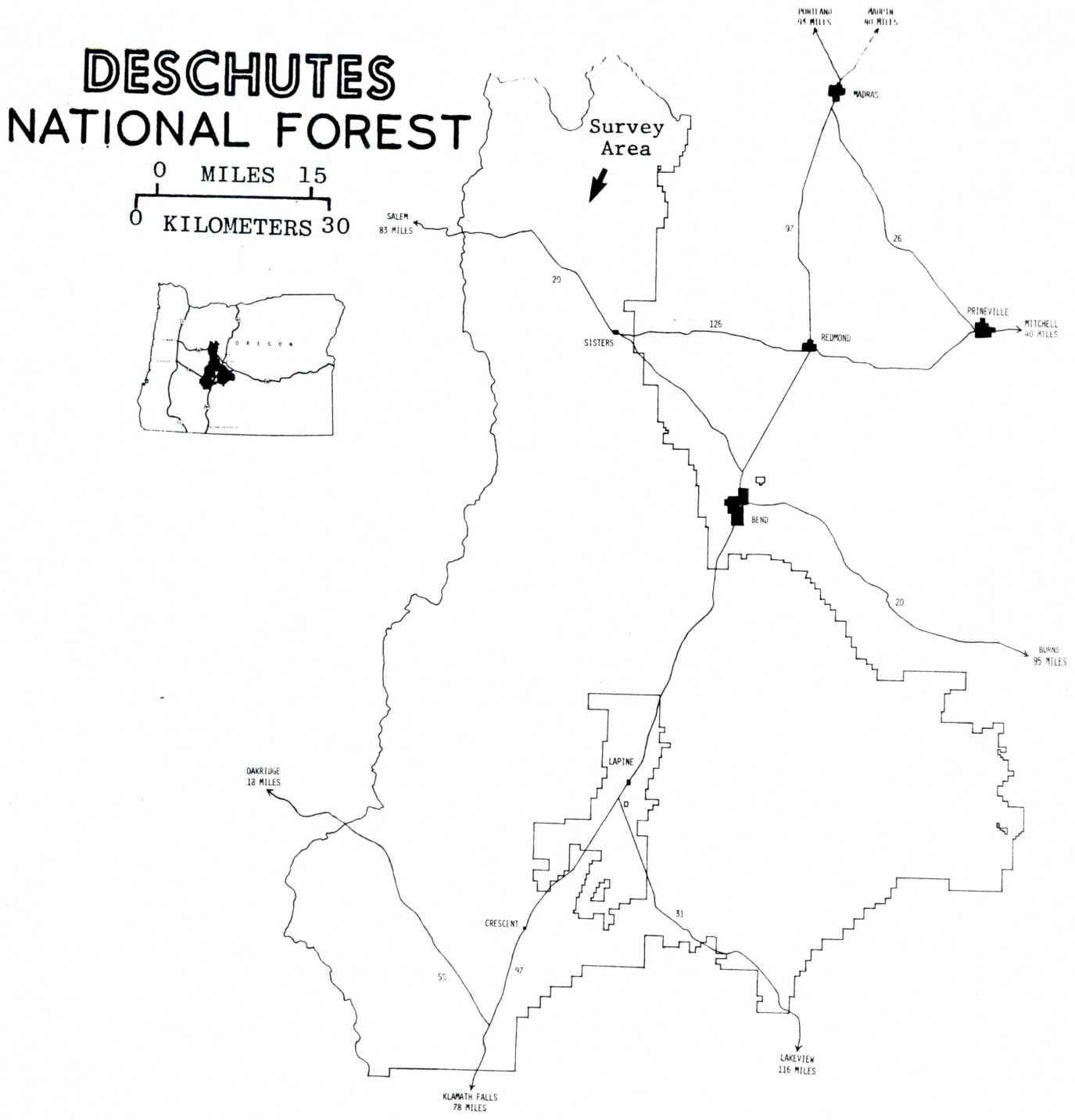
DESCHUTES
NATIONAL FOREST
0 MILES 15
0 KILOMETERS 30
Survey Area
OREGON
PORTLAND 95 MILES
SALEM 83 MILES
MADRAS
PRINEVILLE
MITCHELL 40 MILES
SISTERS
REDMOND
BEND
BURNS 95 MILES
LAPINE
OAKRIDGE 18 MILES
CRESCENT
KLAMATH FALLS 78 MILES
LAKEVIEW 116 MILES
97
26
20
126
31
58

Figure 7.

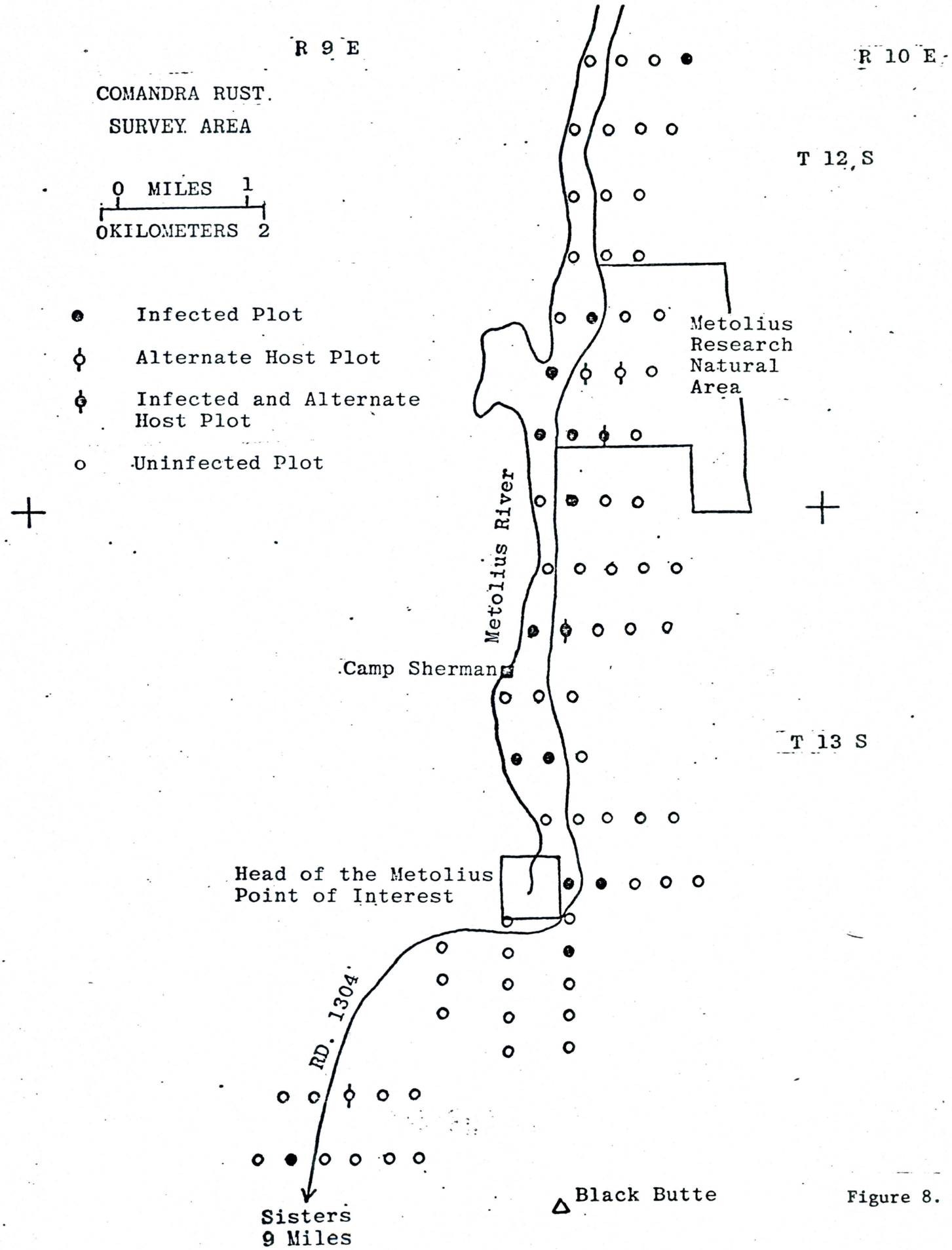
R 9 E
R 10 E
COMANDRA RUST.
SURVEY AREA
T 12 S
0 MILES 1
0KILOMETERS 2
Infected Plot
Alternate Host Plot
Infected and Alternate Host Plot
Uninfected Plot
Metolius Research Natural Area
Metolius River
Camp Sherman
T 13 S
Head of the Metolius Point of Interest
RD. 1304
Black Butte
Sisters 9 Miles

Figure 8.

0 = no evidence of comandra rust
1 = branch canker
2 = stem canker
3 = stem canker with branch kill
4 = thinning crown
5 = dead-top, comandra rust
6 = dead tree, comandra rust
7 = dead-top, other
8 = dead tree, other

Top-kill due to comandra rust can be distinguished from top-kill caused by other agents such as dwarf mistletoe, porcupines, bark beetles, and drought. Necrosis caused by other agents occurs only above the point of initial killing and is often followed by erection of a branch to form a new leader. Necrosis caused by comandra rust occurs initially above the point of incipient killing but moves down the stem as the fungus descends and is never followed by development of a new leader. Remains of branches on rust-killed tops, ranging from short stubs at the top to complete systems including twigs at the bottom, indicate disease advancement and killing down the stem (Figure 5).

For each tree with a rust-killed top, the following additional data were recorded: (1) height of living portion of stem, and (2) basal diameter of dead top. A Spiegel Relaskop was used to measure basal diameter of dead tops from the ground.

Cubic volume of dead-tops were calculated using Smalian's formula; $V=0.5(B+b)\ h$ where V=volume in meters^3 (feet^3), B=basal area in meters^2 (feet^2) of bottom-end of dead-top, b=0=basal area of top-end of dead-top (tops were reconstructed to a point if broken), and h=length of dead-top in meters (feet).

All data were tabulated by computer using the Stand Examination System, Version Four of the U.S. Forest Service, Region 6, Portland, Oregon, the program used to analyze all stand exams conducted on National Forests in Oregon and Washington.

Results

Only infections manifested as top-kill were detected in the evaluation, and all dead-tops were attributed to comandra rust. Some infections may not have produced visible symptoms. Also, although branch flagging and thinning crowns were noted in large diameter trees, these symptoms could not be used as reliable indicators of comandra rust infection without closer inspection. Most of the stand was infected with dwarf mistletoe *(Arceuthobium campylopodum)* which causes similar symptoms. Comandra rust infection percentages may, therefore, be somewhat conservative. Dead trees accounted for less than 1 percent of the total, and none could be positively attributed to comandra rust.

One percent of the stems (10.3 trees/ha, 4.2 trees/ac), representing 6 percent of both cubic (11.6 m^3/ha, 164.7 $ft.^3$/ac) and board foot[1/] (1,050 bd. ft./ac) volumes, were infected with comandra rust (Table 1). Highest incidence of infection occurred in commercial sawtimber (27.8-53.1 cm, 11.0-20.9 in d.b.h.). No infection was detected in smaller diameter trees (0-12.4 cm, 0-4.9 in d.b.h.). Dead-tops accounted for an average of 4.4 percent cubic volume loss per infected tree (range <0.1 percent to 31.6 percent) (Table 2). A small portion of this volume, however, was above the minimum top diameter for merchantability.

Nineteen percent of the plots had at least one rust-infected tree (Figure 8). The alternate host was detected on only 6 percent of the plots. Twenty-two percent of the plots with rust-infected trees had the alternate host present. Most infected trees were found in lower and middle elevation plots. Because overall incidence of infection was low, this correlation was statistically insignificant. Also, rust incidence appeared greater on more gentle slopes, although slope severity often increased with elevation. No correlation could be determined between rust incidence and aspect, since all plots had a westerly exposure.

Analysis of variance between plot parameters and percent of rust infection on each plot shows a significant (P=0.01) correlation with mean tree d.b.h. per plot but none with elevation, percent stocking, trees per acre, or presence of alternate host. Correlation coefficients (r) were low and ranged from 0.09 to 0.29.

1/Scribner Rule

Table 1.--Number of stems and volume of comandra rust-infected ponderosa pine per unit area by size class.

	Healthy				Infected				Total	
	Stems		Volume		Stems		Volume		Stems	Volume
0.0 - 0.9 in	733.8[1/]	(100%)	- [3/]		0		-		733.8	-
0.0 - 2.3 cm	1,812.5[2/]		- [4/]		0		-		1,812.5	-
			- [5/]				-			-
1.0 - 4.9 in	16.3	(100%)	-		0		-		16.3	-
2.4 - 12.4 cm	40.3		-		0		-		40.3	-
			-				-			-
5.0 - 10.9 in	22.9	(93%)	-		1.7	(7%)	-		24.6	-
12.5 - 27.7 cm	56.6		97.6	(94%)	4.2		6.4	(6%)	60.8	104.0
			6.8				0.5			7.3
11.0 - 20.9 in	8.1	(82%)	1,570.0	(98%)	1.8	(18%)	29.0	(2%)	9.9	1,599.0
27.8 - 53.1 in	20.0		355.6	(98%)	4.4		6.8	(2%)	24.4	362.4
			24.9				0.5			25.4
21 in +	12.6	(95%)	14,364.0	(93%)	0.7	(5%)	1,021.0	(7%)	13.3	15,385.0
53.2 cm +	31.1		2,202.5	(94%)	1.7		151.5	(6%)	32.8	2,354.0
			154.2				10.6			164.8
TOTAL	793.7	(99%)	15,934.0	(94%)	4.2	(1%)	1,050.0	(6%)	797.9	16,984.0
	1,960.5		2,655.7	(94%)	10.3		164.7	(6%)	1,970.8	2,820.4
			185.9				11.6			197.5

1/Stems per acre
2/Stems per hectare
3/Board feet (Scribner) per acre
4/Cubic feet per acre
5/Cubic meters per hectare

Table 2.--Wood volume loss as dead-tops due to comandra rust in ponderosa pine.

Volume per tree	Volume per dead-top	Percent loss
1.8[1/]	<0.1	<0.1
0.1[2/]	<0.1	
9.0	0.4	4.4
0.3	<0.1	
37.8	0.1	0.3
1.1	<0.1	
88.2	27.9	31.6
2.6	0.8	
160.2	1.4	0.9
4.8	<0.1	
160.2	18.2	11.4
4.8	0.5	
189.0	11.2	5.9
5.7	0.3	
189.0	2.7	1.4
5.7	0.1	
189.0	9.1	4.8
5.7	0.3	
220.2	0.7	0.3
6.6	<0.1	
220.2	16.0	7.3
6.6	0.5	
253.8	20.9	8.2
7.6	0.6	
289.8	24.7	8.5
8.7	0.7	
289.8	8.6	3.0
8.7	0.3	
289.8	7.5	2.6
8.7	0.2	
328.2	3.3	1.0
9.8	0.1	
412.2	16.0	3.9
12.4	0.5	
556.2	1.6	0.3
16.7	<0.1	
TOTAL 3,884.4	170.3	4.4
116.6	5.1	

1/Cubic feet

2/Cubic meters

Discussion

Comandra rust incidence in the survey area appears exclusively as top-kill (spike-tops), primarily in mature and overmature ponderosa pines. Apparently, infection and top-kill are not recent, because extensive deterioration is now present in many dead-tops. Increment cores from "spike-top" trees indicate a marked decline in tree growth for the last 40 years, the probable period that tops were dead.

Recent infections are absent in smaller diameter plot trees, although a few examples were noted outside the plots. Young-growth trees infected in the past may have died and disappeared from the stand. It appears, therefore, that most rust infection occurred in the past and relatively little is occurring presently. Pine infections by comandra rust have been reported to occur in "wave years" at intervals of 10 to 20 years, when conditions are favorable for disease spread (Meinecke 1928; Childs 1968). Apparently, favorable conditions for infection have not existed in recent years. Specific conditions favoring rust infection in ponderosa pine stands are unknown. Knowledge of such conditions would be useful to predict future infection.

Infrequent occurrence of bastard toadflax in the survey area may partially explain lack of recent infections, since the alternate host is required in the infection process. Bastard toadflax is favored by open, dry conditions, which may have been more prevalent in the past. Wildfires in ponderosa pine stands may have created and maintained such openings which are infrequent today because of present fire exclusion policies. Overgrazing by cattle may also have increased the incidence of bastard toadflax, since the plant is not readily eaten (Laycock and Krebill 1967).

Rust-killed tops in the survey area represent a relatively small loss in overall wood volume. Loss due to decelerated growth of infected trees, although not measured, may be significant, however.

Recommendations

Although recent infections and infections on small diameter trees were not found in the survey area, favorable conditions for infection may occur in the future, causing potential crop tree loss. Vigorous, young trees are infected more readily than poor trees (Childs 1968). Mortality due to comandra rust in young-growth pine can result in an understocked stand. Future infection and mortality in young-growth stands can be minimized by: (1) thinning recently infected trees and (2) using only local planting stock, since native trees are probably less susceptible to rust infections than nonlocal stock.

Although control through eradication of the alternate host is not practical, factors which may lead to a decline in bastard toadflax incidence include: (1) conditions which limit openings in stands, (2) overgrazing by sheep and deer, and (3) severe infection by comandra rust which kills the alternate host (Meinecke 1928).

Many old-growth ponderosa pine with rust-killed tops have been retained in the survey area for aesthetic value. Hazard due to breakage increases with time since top-kill. Large tops with basal cracks or woodpecker holes should be removed or jeopardized sites reestablished especially in areas of high public occupancy (campsites, etc.). In other areas, unless the remaining crown of an infected tree is of poor vigor or killing has progressed so far that little live crown remains, trees can be retained until the next scheduled harvest entry. Such trees appear to be no more susceptible to attacks by bark beetles, root rots, or other pests than noninfested trees (Childs 1968).

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